AFQTP 3E5X1-12
1 MAY 01

AIR FORCE

QUALIFICATION TRAINING PACKAGE (AFQTP)

for

ENGINEERING

(3E5X1)

MODULE 12

SURVEYING

TABLE OF CONTENTS

MODULE 12

SURVEYING

Career Field Education and Training Plan (CFETP) references from 1 Apr 97 version.

OPR: HQ AFCESA/CEOF
(SMSgt Pat Abbott)

Certified by: HQ AFCESA/CEO
(Colonel Lance C. Brendel)

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

AIR FORCE QUALIFICATION TRAINING PACKAGES
for
ENGINEERING
(3E5X1)

INTRODUCTION

Before starting this AFQTP, refer to and read the "Trainee/Trainer Guide" located on the AFCESA Web site **http://www.afcesa.af.mil/**

AFQTPs are mandatory and must be completed to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks.

MANDATORY minimum upgrade requirements:

Core task:
AFQTP completion
Hands-on certification

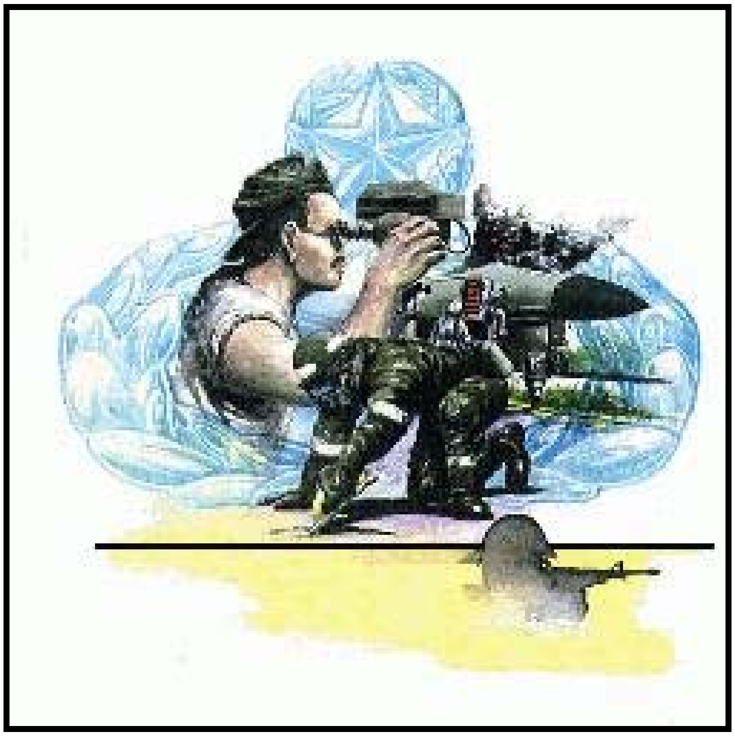
Diamond task:
AFQTP completion
CerTest completion (80% minimum to pass)

Note: *Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location.*

Put this package to use. Subject matter experts under the direction and guidance of HQ AFCESA/CEOF revised this AFQTP. If you have any recommendations for improving this document, please contact the Career Field Manager at the address below.

HQ AFCESA/CEOF
139 Barnes Dr. Suite 1
Tyndall AFB FL 32403-5319
DSN: 523-6322, Comm: (850) 283-6322
Fax: DSN 523-6488
E-mail: ceof.helpdesk@tyndall.af.mil

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.



ESTABLISH HORIZONTAL ALIGNMENT

MODULE 12 AFQTP UNIT 1

ESTABLISH HORIZONTAL CONTROL (12.1.3.)

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

ESTABLISH HORIZONTAL CONTROL

Task Training Guide

STS Reference Number/Title:	12.1.3. Establish horizontal control
Training References:	• FM 5-233, TM 5-441, TM 5-442, TM 5-443, Surveying Fourth Edition by Jack McCormac
Prerequisites:	• Possess as a minimum a 3E531 AFSC • Must have a basic knowledge of surveying and drafting prior to entering into upgrade • Must have completed volume 4. Plane Surveying of the 3E551A Engineering Journeyman Career Development Courses
Equipment/Tools Required:	• 100' steel tape, transit, theodolite or total station instrument, prism, GPS (optional), range pole, taping arrows, tension scale, tension handle, scissors clamp, hand or engineer level, leveling rod, axes, hatches, or machetes, plumb bob, hub, guard stakes, thermometer, traverse computation sheet, and calculator
Learning Objective:	• The trainee will be able to establish horizontal control
Samples of Behavior:	• The trainee will be able to measure horizontal angles and distances • The trainee will be able to accurately complete an open and closed traverse • The trainee will be able to complete a Traverse Computation Sheet

Notes:

- For training purposes, have trainee re-accomplish previously completed traverses
- Use hands-on training to accomplish learning objective
- Train to a go no-go level

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

ESTABLISH HORIZONTAL CONTROL

Background: Survey points must be located relative to some type of control system--local, national or worldwide. The position of the point will be established with some degree of permanency. Relative positions of points can be determined within a local control system (state or municipal). If such control is tied into geodetic control, positions of the points can be computed with respect to national or worldwide systems or by the use of a Global Positioning System (GPS). The main control scheme is a network either of triangulation or traverses based on the Compass Rule. These should be near the points to be tied in to reduce supplementary control requirements. Supplementary control consists of short traverse or triangulation lines that run close to or across a project area. These stations must be established to a degree of accuracy required by the survey's purpose. If a main control scheme must be run first, it should be accurate enough for the supplementary survey to furnish proper accuracy for the detail.

- **Traverse** Classified as either *open* or *closed*. The purpose of the traverse will usually govern whether its stations will be marked permanently or temporarily. When you know that a traverse station may be reused for several years, use a permanent station marker, otherwise use temporary marking.

  Closed Closed, when referring to traverses, doesn't mean the traverse describes a polygon. It means the end of the traverse closes on a known point.

  Open An open traverse ends at a station whose relative position is not previously known and provides no checks against mistakes or large errors.

To perform this task, follow these steps:

Step 1: Reconnaissance Use the best available maps and aerial photographs during both office and field reconnaissance.

- **Select start and closing points.** Your starting point should be an existing control station that was determined by a survey with order of accuracy equal to or greater than the traverse to be run. A second existing control station, visible from the first, should be used to orient the new traverse. If no nearby station exists, the starting point must be determined by some other method (for example GPS). It may be assigned an assumed position, or you may have to determine the position from observation of stars (TM 5-442).

- **Route selection.** Traverses are usually run to establish new stations (control) in the area. Location of the required stations is specified, at least in terms of vicinity or distance between stations. Clearing for traverse lines should be kept to a minimum. When in a contingency environment, some mass clearing may be acceptable if force protection or speed of survey completion is required. In most peacetime operations where traverse lines are run through private property, indiscriminate tree cutting isn't allowed.

Step 2: Set-up procedures for instrument.

- Set up tripod over starting station
- Attach instrument to tripod
- Plumb instrument over station
- Level instrument

Step 3: Field procedures.

- Backsight to rear station
- Initialize the horizontal angle on the rear station
- Turn angle clockwise to the forward station
- Record horizontal angle value in field notebook
- Measure linear distance to forward station
- Record linear distance value in field notebook

NOTE:
To continue traverse, move to forward station and repeat steps 2 & 3 until reaching closing point.

Step 4: Complete Traverse Computation Sheet (for enlarged version of the sheet, refer to Foldouts 1-3 of the Engineering Journeyman 3E551A Career Development Course, Volume 4, Supplementary Material.

- Sketch the layout of the survey in the area provided at the bottom left hand corner of the transverse computation sheet

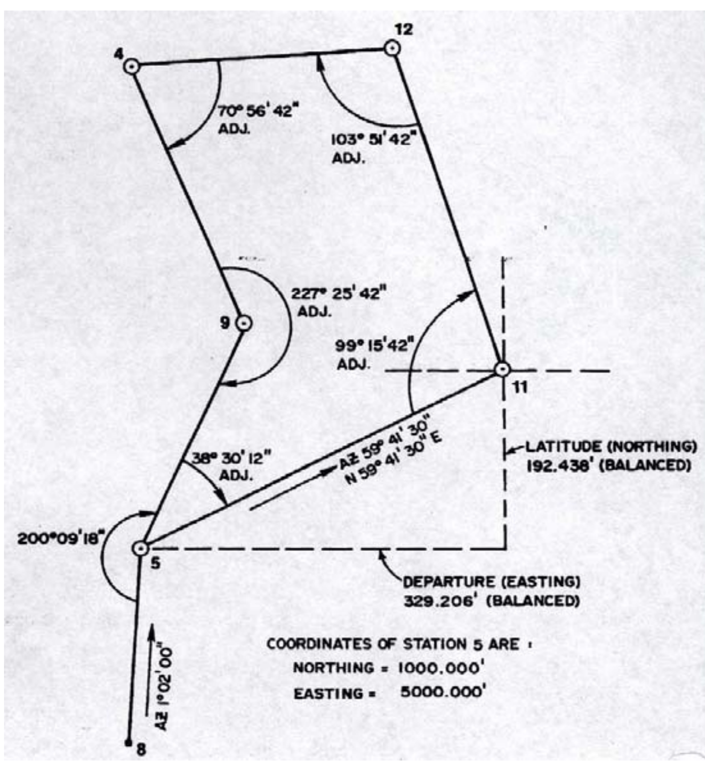


Figure 1

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

- Number the stations on the sketch to correspond with your field notes
- Record station data in column 1 as per figure 2
- Record linear distance between stations in column 2
- Record horizontal angle value, between rear and forward stations, in column 3
- If a closed traverse has been accomplished, compute the adjusted angles between stations using the following steps and enter adjusted angles in column 4

  1. Compute the measured sum of the interior angles by adding all angles in column 3.
  2. Compute the mathematical sum of the interior angles by subtracting 2 from the total number of sides in the polygon, then multiply that number by 180º. (N-2) 180
  3. If the measured sum equals 540º 01' 30", subtract 540º 00' 00" to get 0º 01' 30" as our angular error of closure (AEC).
  4. Divide the AEC by the number of interior angles in your polygon.
  5. Since the measured sum is greater than the mathematical sum, subtract the adjustment calculated in step 4 from each angle in column 3 of the worksheet. If the measured sum is less than the mathematical sum, add the adjustment to each angle in column 3. Enter the adjusted angles in column 4.

- Compute the azimuth of each line using the known azimuth from the control points and enter value in column 5.
- Compute the bearing of each line using the azimuth in column 5 and enter the value in column 6.
- Using your calculator, compute the cosine and sine of each bearing angle and enter those values in columns 7 & 8, respectively.
- Calculate the latitude (distance north and south) and departure (distance east and west) by multiplying, respectively, the cosine and sine of the bearing times the distance of the traverse line. Enter those values in columns 9 through 12.

Note:
The latitude N 59º 41' 30" E is north (positive) and the departure is east (positive). South and west directions are negative. Be sure to use the correct column. If you don't, the linear error of closure (LEC) will not compute.

- Apply a correction to the latitudes and departures using the following steps:

  1. Total the values in column 9 through 12 as per figure 2.
  2. Calculate the difference between columns 9 & 10 ΔY's, and columns 11 & 12 ΔX's.
  3. Calculate the LEC using the following formula:
     LEC = Square Root of (ΔY squared + ΔX squared)
  4. Calculate the Precision using the following formula:
     Precision = total distance in column 2 divided by the LEC

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

5. Calculate the latitude correction per foot by using the following formula:

   Latitude correction = ΔY divided by total distance in column 2

6. Calculate the departure correction per foot by using the following formula:

   Departure correction = ΔX divided by the total distance in column 2

- Balance latitudes using the following steps:

  1. Multiply the correction for latitude times the distance (column 2), and apply this product to the latitude (column 9 or 10) to find the balanced latitude (column 13).
  2. If the total north latitudes are larger than the total south latitudes, subtract corrections from north and add to south.
  3. If the total south latitudes are larger, add corrections to north and subtract from south.

- Balance departures exactly the same as latitudes, multiply the correction for departure times the distance (column 2), and apply this product to the departure (column 11 or 12) to find the balanced departure (column 14). If the total east departures are larger than the total west departures, subtract corrections from the east and add to the west. If total east departures are less than the total west departures, add corrections to the east and subtract from the west.

Note:
North latitudes are positive and south latitudes are negative. East departures are positive and west departures are negative.

- Using the northing and easting from your control point, calculate the new northings and eastings using the following steps:

  1. Start with the known or assumed coordinates for your control point and algebraically add the balanced latitudes (column 13) to the northings.
  2. Algebraically add the balanced departures (column 14) to the eastings.

CHECKED BY HESS
CALCULATED BY STACK
SURVEYED BY ROLAND

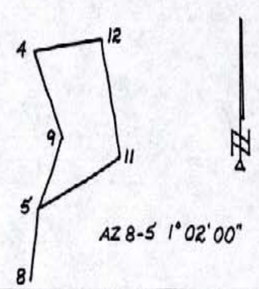
TRAVERSE COMPUTATION SHEET

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
STA	DIST	ANGLE		AZIMUTH	BEARING	COS BEARING	SIN BEARING	LATITUDE		DEPARTURE		BALANCED		COORDINATES	
		UNADJUSTED	ADJUSTED					+ΔY NORTH	-ΔY SOUTH	+ΔX EAST	-ΔX WEST	LAT +N -S	DEP +E -W	Y NORTHINGS	X EASTINGS
5—8				181° 02' 00"										1000.000	5000.000
		200° 09' 18"													
9															
5—9															
	381.33	38° 30' 30"	38° 30' 12"	59° 41' 30"	N59°41'30"E	.504653	.863322	192.439		329.211		192.436	329.206		
11														1192.436	5329.206
11—5															
	329.15	99° 16' 00"	99° 15' 42"	338° 57' 12"	N21°02'48"W	.933288	.359128	307.192			118.207	307.190	-118.211		
12														1499.626	5210.995
12—11															
	244.74	103° 52' 00"	103° 51' 42"	262° 48' 54"	S82°48'54"W	.125073	.992147		30.610		242.818	-30.612	-242.821		
4														1469.014	4968.174
4—12															
	270.49	70° 57' 00"	70° 56' 42"	153° 45' 36"	S26°14'24"E	.896950	.442132		242.616	119.592		-242.618	119.589		
9														1226.396	5087.763
9—4															
	242.81	227° 26' 00"	227° 25' 42"	201° 11' 18"	S21°11'18"W	.932397	.361435		226.395		87.760	-226.397	-87.763		
5								499.631	499.621	448.803	448.785			999.999	5000.000
		540° 01' 30"						ΔY=	.010	ΔX=	.018				
		540° 00' 00"													
		1' 30"	AEC												
		18"	ADJ PER ∡												
	1468.52														

$LEC = \sqrt{.010^2 + .018^2} = .020591$

PRECISION $= \dfrac{1}{\frac{1468.52}{.020591}} = \dfrac{1}{71318.537} = 1 : 71319$

SKETCH



LATITUDE CORRECTION PER FT $= \dfrac{.010}{1468.52} = .000007$

DEPARTURE CORRECTION PER FT $= \dfrac{.018}{1468.52} = .000012$

Figure 2

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

Review Questions
for
Establish Horizontal Control

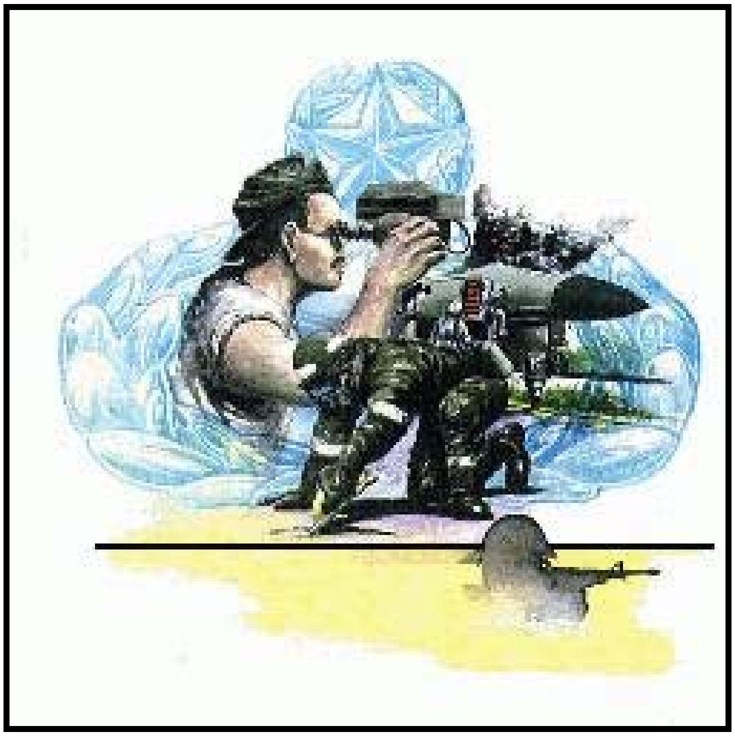
Question	Answer
1. What is a traverse?	Written answer
2. What are the two kinds of traverse?	a. Connecting and Loop b. Convex and Loop c. Open and Closed d. Connect 4 format and Loop
3. North latitudes are positive and south latitudes are negative.	a. True b. False
4. East departures are negative and west departures are positive.	a. True b. False
5. What does the term closed traverse mean?	Written answer
6. A closed traverse provides no checks against mistakes or large errors.	a. True b. False

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

ESTABLISH HORIZONTAL CONTROL

Performance Checklist		
Step	**Yes**	**No**
1. Reconnaissance • Selected start and closing points • Selected a good route		
2. Instrument setup • Proper tripod setup • Attachment of instrument correct • Leveling procedures correct • Instrument plumb over starting point		
3. Field procedures • Instrument initialized on rear station • Horizontal angle properly read and annotated • Linear distance properly read and annotated		
4. Complete traverse computation sheet • Sketch accurately reflects survey • Information properly transferred from field notebook to worksheet • Adjusted angles properly compute • Azimuth of each line computed properly • Bearing of each line computed properly • Sine and Cosine of bearing angle properly computed • Latitude correctly computed • Departure correctly computed • Properly applied corrections to Latitudes and Departures • Properly balanced Latitudes and Departures • Calculated Northings and Eastings properly		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.



ESTABLISH VERTICAL ALIGNMENT

MODULE 12 AFQTP UNIT 2

ESTABLISH VERTICAL CONTROL (12.2.3.)

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

ESTABLISH VERTICAL CONTROL

Task Training Guide

STS Reference Number/Title:	12.2.3. Establish Vertical Control
Training References:	• FM 5-233, TM 5-441, TM 5-442, TM 5-443
Prerequisites:	• Possess as a minimum a 3E531 AFSC • Must have completed volume 4, Plane Surveying of the 3E551A Engineering Journeyman Career Development Courses
Equipment/Tools Required:	• Engineer level, leveling rod, axes, hatches, or machetes, plumb bob, hub, guard stakes, thermometer, calculator, and field notebook
Learning Objective:	• The trainee will be able to establish vertical control.
Samples of Behavior:	• The trainee will be able to transfer vertical control from a known point to an unknown point with third order accuracy. • The trainee will be able to complete a level circuit.
Notes:	
• Train to a go/no go level	

ESTABLISH VERTICAL CONTROL

Background: Very few, if any, construction projects can be completed based on horizontal position only. Vertical positions must also be known. A body of still water will assume a level surface. If changes in the ocean's surface, caused by such influences as tides, currents, winds, atmospheric pressure, and the rotation of the earth could be eliminated, the resulting surface would be level. The ocean's level tidal height observations are determined over a Metonic cycle (approximately 19 calendar years). This average, called mean sea level, is the most common datum for leveling and is usually assigned an elevation of zero. This datum remains in effect until continuing observations show a significant difference, and it becomes worthwhile to change to a new datum. In the United States, the mean sea level datum of 1929 is still in effect.

Types of Leveling Leveling is divided into two major categories, *direct* and *indirect*.

- **Direct Leveling** Direct leveling is usually referred to as differential or spirit leveling. In this method the difference is elevation between a known elevation and the height of instrument, and then the difference in elevation from the instrument height to an unknown point are determined by measuring the vertical distance with a precise or semi-precise level and leveling rods. This is the only method that will yield accuracy of third or higher order.

- **Indirect Leveling** There are two methods of doing indirect leveling, *trigonometric* and *barometric*.

    - **Trigonometric** This method applies the fundamentals of trigonometry to determine the differences in elevation by observing vertical angles (above or below a horizontal plane) and a horizontal distance (measured or computed) to compute the vertical distance between points. This method is generally used for lower order leveling where the terrain is prohibitive to direct leveling.

    - **Barometric** This method uses the differences in atmospheric pressure as observed with a barometer or altimeter to determine the differences in elevation between points. This is the least used and least accurate method of determined differences in elevations. This method should only be used in surveys when one of the other methods is unfeasible or would involve great expense in time or money. Generally in surveying, this method is used for small scale mapping projects and field surveys as necessary.

Step 1: Reconnaissance Use the best available maps and aerial photographs during both office and field reconnaissance.

- **Select start and closing points** Your starting point should be an existing control station that was determined by a survey with order of accuracy equal to or greater than the traverse to be run. A second existing control station, visible from the first, should be used to orient the new traverse. If no nearby station exists, the starting point must be determined by some other method. It may be assigned an assumed position, or you may have to determine the position from observation of stars (TM 5-442).

- **Route Selection** Traverses are usually run to establish new stations (control) in the area. Location of the required stations is specified, at least in terms of vicinity or distance between stations. Clearing for traverse lines should be kept to a minimum. When in a contingency environment, some mass clearing may be acceptable if force protection or speed of survey completion is required. In most peacetime operations, where traverse lines are run through private property, indiscriminate tree cutting isn't allowed.

Step 2: Set-up procedures for instrument

- Set up instrument at a point between the start and closing point.

> **Note:**
> This point should be no more than 300 feet from your start point. It also must allow for a clear line of sight to the start point.

- Place auto-level on tripod and secure.
- Level instrument using the leveling screws and circular bubble.

Step 3: Field Procedures.

- Record elevation of starting point in field notebook.
- Rodman holds a rod vertically on the start point with a known elevation.
- Instrument man makes a level reading through the telescope on the Philadelphia rod (this is known as a backsight or BS) also make a stadia distance reading.
- Record these readings in the field notebook.
- Add the BS to the known elevation of the starting point; this gives you the height of instrument or HI.
- Rodman now moves to a point between the instrument and the closing point.

> **Note:**
> This point should be approximately the same distance the instrument was set up from the BS. This procedure should be continued throughout the level circuit. This will prevent possible error in line of sight adjusting.

- Instrument man now rotates instrument to focus on the new rod position and takes a level reading through the telescope (this is known as a foresight FS) also make a stadia distance reading.
- Record these readings in the field notebook.
- Subtract the FS from the HI; this will give you the elevation of the point the rod is setting on.

> **Note:**
> It is very important to remember that backsight are always added and foresights are always subtracted. This will prevent errors in calculating your final elevation.

- After completion of the foresight reading, the instrument man now moves to a new position between the rod and the closing point and repeats the setup procedures in Step 2. The existing rod position now becomes the backsight.
- Repeat the process in Step 3 until the elevation is transferred to the closing point.

Note:
It is always good practice to close your survey to a point of known elevation. This may require you to return to your original starting point or continue on to a different point with a known elevation.

Step 4: Determining the adjusted elevation.

- Total the backsight readings in the field notebook.
- Total the foresight readings in the field notebook.
- Find the difference between the BS column and the FS column.
- Find the difference between the beginning known elevation and the ending known elevation.
- Compare the two differences; if they are different, an error has been made in determining the height of instrument or elevations.
- Total the distance column in the field notebook, and convert it to miles using the following formula:
  Distance column total / 5280 ft = xx.xx miles (M)
- Calculate the allowable error of closure (AEC) using the following formula.
  AEC = +/- 0.05 (square root of M)
- Find the difference between the ending point known elevation and your computed ending point elevation.
- If the difference is within the limits of the AEC, the survey meets the accuracy requirements for a third order survey. If the difference is not within the limits of the AEC, the survey must be redone.
- Take the difference and divide it by the number of set-ups; this will give you the adjustment.
- If the computed elevation is too low, add adjustments. If the computed elevation is too high, subtract adjustments.
- Add one fraction of the total error (the computed adjustment) to the first set-up elevation.
- Add two fractions of the total error to the second set-up elevation and three to the third.
- Continue this process until you complete the adjustments to all set-ups, the final set-up should have the entire adjustment added to it.

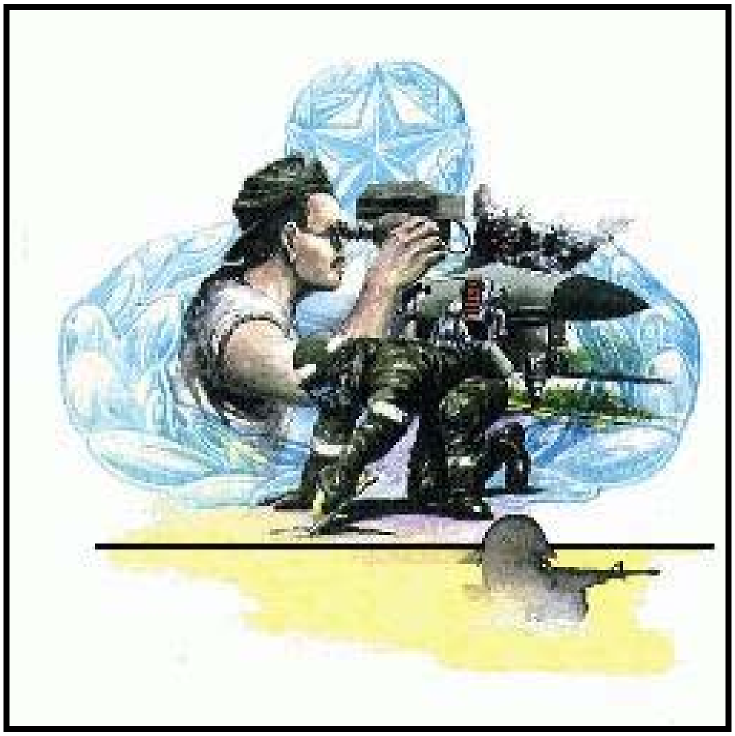
Review Questions
for
Establish Vertical Control

Question	Answer
1. What are the two methods for performing indirect leveling?	a. Trigonometric and barometric b. Trigonometric and geometric c. Algometric and barometric d. Thermometric and barometric
2. What are the two major categories of Leveling?	a. Horizontal and vertical b. Trigonometric and barometric c. Direct and Indirect d. Vertical and diagonal
3. Backsights are always subtracted from the known elevation.	a. True b. False
4. You should always attempt to balance your backsight and foresight distances.	a. True b. False
5. To close a level circuit you may return to your starting point or continue to another point of known elevation.	a. True b. False

ESTABLISH VERTICAL CONTROL

Performance Checklist		
Step	**Yes**	**No**
1. Reconnaissance • Select start and closing points • Selected a good route		
2. Instrument setup • Proper tripod setup • Attachment of instrument correct • Leveling procedures completed		
3. Field procedures • Made a proper backsight reading • Made a proper stadia reading • Properly calculated the height of instrument • Made proper foresight reading • Properly calculated the elevation at the new location		
4. Determining the adjusted elevation • Verified backsight and foresight differences equal the known elevation difference • Properly converted total distance to miles • Properly calculated the AEC • Determined if the survey met third order accuracy • Properly calculated the adjustment • Properly applied the adjustment		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.



SURVEYING

MODULE 12 AFQTP UNIT 3

PERFORM SITE RECONNAISSANCE (12.3.)

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

PERFORM SITE RECONNAISSANCE

Task Training Guide

STS Reference Number/Title:	12.3. Perform Site Reconnaissance
Training References:	• FM 5-233, AFPAM 10-219 • Surveying with Construction Applications
Prerequisites:	• Possess as a minimum a 3E531 AFSC • Must have a basic knowledge of surveying and drafting prior to entering into upgrade • Must have completed volume 4. Plane Surveying of the 3E551A Engineering Journeyman Career Development Courses
Equipment/Tools Required:	• Recording forms, radios, binoculars, measuring tape and marking materials, resource charts and records, intelligence reports, topographic maps, and photos if possible
Learning Objective:	• The trainee will be able to perform site reconnaissance
Samples of Behavior:	• The trainee will be able to identify possible candidates for road or airfield reconnaissance

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

PERFORM SITE RECONNAISSANCE

Background: A reconnaissance survey consists of an extensive study of an entire area that might possibly be used for construction. It should include, but not be limited to, a preliminary survey and *soils exploration* and *field identification*. This will vary according to the size and scope of project under consideration. Aspects such as mission, type, volume of traffic, people, and length of the road or airfield have to be considered when undertaking the reconnaissance. These requirements will aid in identifying any possible special equipment requirements and allow an estimation of the time needed for construction. It is important that all possible routes and sites in the area be covered thoroughly in order to economize. A reconnaissance report should be a summary of all data collected including possible routes, sites and their usability, maps, and photographs if possible.

Types Of Surveys There are three types of reconnaissance surveys that may be used for construction, *engineer, road,* and *airfield*. All three types will have separate considerations for their specific type construction. As engineering assistants, we will be concerned only with road and airfield reconnaissance.

To perform Site Reconnaissance for the Airfield, follow these steps:

Step 1: Determine feasibility

Ensure the airfield is both feasible engineering-wise and suitable for the air traffic which will use it.

Step 2: Preliminary study

- Collect as much data as possible before the actual survey begins.
- Study available maps and aerial photos to yield extensive information on terrain, vegetation, water sources, obstacles, and site access.
- Gather intelligence reports on the area, along with agricultural and topographic maps. Gather data on weather conditions, local economic conditions, and local population.
- When possible, local inhabitants are interviewed both as a check on information already obtained and as a source of further information. When possible, several separate opinions should be obtained. Questions should be phrased differently to different persons to provide the best basis for cross comparison of the answer. Information thus obtained must be weighed carefully and cautiously with due regard for apparent creditability of each person.

NOTE:
Analysis of all data collected is going to vary depending on the type of construction being accomplished. Airfields, roads, and facilities all have different aspects to be considered.

Step 3: Select map

Select the best available map of the area in which the new airfield is to be located.

Step 4: **Identify airfield**

Draw a five-mile circle around existing airfields and shade these circles.

Step 5: Identify obstructions

Note all high-tension electric transmission lines and shade a two-mile wide strip centered on all lines and other obstructions similar in nature.

Step 6: Identify possible candidates

- Look for sites of sufficient area preferably flat with good natural drainage, unobstructed air approaches, and accessibility to routes of communication.
- Assign the most likely sites to reconnaissance parties for appropriate air and ground investigation.

Step 7: Investigate candidates

Perform a complete ground reconnaissance of possible routes to ensure selection of the best route. When the site is reached, investigate the most likely possibilities for a runway.

Step 8: Record findings

Perform a rough survey of each selected runway; pace lengths, measure critical slopes, and determine magnetic directions.

Step 9: Make selection

- Select the best runway with consideration to prevailing wind direction, air approaches, and glide angles, ground water conditions, discharge areas for collected runoff, and earthwork.
- Make a careful and detailed walk of the centerline to check suitability.
- Drive stakes at each end of the runway and properly reference to expedite location.
- Stake out the centerline and at each shoulder line.
- Take level readings at 500-foot intervals and immediate break or slope changes.
- Perform soil analysis.

Step 10: Submit report

Report findings to your higher headquarters as soon as possible (ASAP) to allow for troop and equipment movement. You may submit the report findings orally, but immediately follow up with a written report.

NOTE:
Reports are submitted for all sites investigated, even if the site is unsuitable in the opinion of the reconnaissance party.

To perform Site Reconnaissance for the road, follow these steps:

Step 1: Determine feasibility

Make sure the new road is absolutely necessary, justified in terms of time and labor.

Step 2: Preliminary study

- Collect as much data as possible before the actual survey begins.
- Study available maps and aerial photos to yield extensive information on terrain, vegetation, water sources, obstacles, and site access.
- Gather intelligence reports on the area, along with agricultural and topographic maps.
- Gather data on weather conditions, local economic conditions, and local population.
- When possible, local inhabitants are interviewed both as a check on information already obtained and as a source of further information. When possible, several separate opinions should be obtained. Questions should be phrased differently to different persons to provide the best basis for cross comparison of the answer. Information thus obtained must be weighed carefully and cautiously with due regard for apparent creditability of each person.

NOTE:
Analysis of all data collected is going to vary depending on the type of construction being accomplished. Airfields, roads, and facilities all have different aspects to be considered.

Step 3: Select route.
Perform a complete ground reconnaissance of possible routes to ensure selection of the best route

Step 4: Record findings.
Note and record general road conditions, bridges, location of repairable railhead, availability of materials and equipment, and potential water supply points.

Step 5: Make selection.
Locate the road that will hold up under anticipated traffic and provide optimum operating conditions.

Step 6: Submit report.
Report findings to your higher headquarters as soon as possible (ASAP) to allow for troop and equipment movement. You may submit the report findings orally, but immediately follow up with a written report.

NOTE:
Reports are submitted for all sites investigated, even if the site is unsuitable in the opinion of the reconnaissance party.

Review Questions
for
Perform Site Reconnaissance

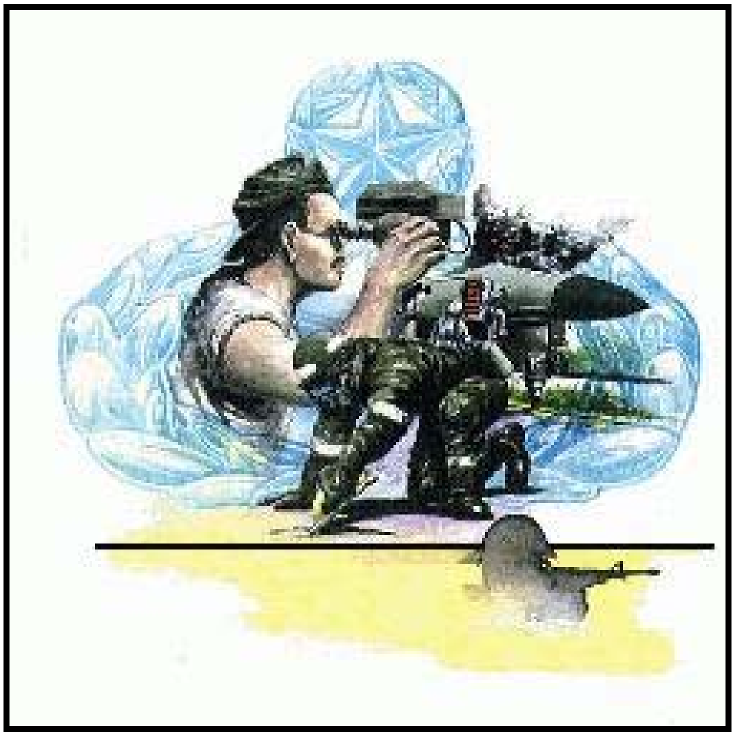
Question	Answer
1. What is the purpose of a reconnaissance survey?	Written answer
2. Preliminary studies include studying maps and gathering reports and data.	a. True b. False
3. Air photos can yield extensive information on terrain, vegetation, water sources, obstacles, and site access?	a. True b. False
4. Reports can be submitted orally and followed up with a written report?	a. True b. False

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

PERFORM SITE RECONNAISSANCE

Performance Checklist		
Step	**Yes**	**No**
1. Determined feasibility?		
2. Performed preliminary study?		
3. Selected map and/or route?		
4. Identified airfields?		
5. Identified obstructions?		
6. Identified possible candidates?		
7. Investigated candidates?		
8. Recorded findings?		
9. Made selection?		
10. Submitted report?		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.



SURVEYING

MODULE 12 **AFQTP UNIT 4**

PERFORM TOPOGRAPHIC SURVEY (12.4.)

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

PERFORM TOPOGRAPHIC SURVEY

Task Training Guide

STS Reference Number/Title:	12.4. Perform topographic survey
Training References:	• FM 5-233, TM 5-541; Surveying with Construction Applications, and Surveying Theory and Practice
Prerequisites:	• Possess as a minimum a 3E531 AFSC • Must have a basic knowledge of surveying and drafting prior to entering into upgrade • Must have completed volume 4. Plane Surveying of the 3E551A Engineering Journeyman Career Development Courses
Equipment/Tools Required:	• Calculator • 100' and 300' measuring tape • Drawing media (Vellum) • Pencil • Triangle • Umbrella • Notebook • Transit or theodolite with tripod • Level rods
Learning Objective:	• The trainee will be able to perform a topographic survey
Samples of Behavior:	• The trainee will be able to determine contours through use of the radiation method by stadia observations
Notes:	
• Due to the availability of equipment and shop uniques, use established in-house steps and procedures to accomplish your hands-on training objective. This pamphlet is designed to reacquaint and/or jog your memory prior to initiating training in this area.	

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

PERFORM TOPOGRAPHIC SURVEY

Background: The purpose of a topographical survey is to document the shape, configuration, relief, roughness, or three-dimensional quality of the earth's surface. Topographical maps are made to show this information, together with the location of artificial and natural features of the earth including buildings, roads, bodies of water, vegetation and so forth. Topographical maps are a critical part of any construction endeavor and is the basis of performing many forms of reconnaissance such as bare base planning and aircraft crash surveys. Resection, intersection, and radiation are commonly used forms of topographical surveying however, regardless of the type used, your results will be a direct reflection of you abilities to apply systemic procedures. Stadia is used to establish horizontal distances since high order accuracy is not required.

The next section will cover the actual plotting of the data. For now we'll focus on the procedures for gathering the actual data.

To perform this task, follow these steps:

Step 1: Make map
Draw a 200' x 200' detail map of the area to be used to perform the topographic survey.

Step 2: Select topographic equipment
Obtain the necessary equipment to perform the survey.

Step 3: Layout grid
Set up a total dimension grid of 200' x 200' with grid points marked at 25' x 25' inside this grid.

Step 4: Establish baseline
Select any two points in the area of the survey. One should be a bench mark with a known elevation.

Step 5: Set-up instrument
Set up the tripod and instrument and level instrument.

Step 6: Observe backsight
Read backsight station to 0.1-foot accuracy and orient baseline to zero on instrument.

Step 7: Compute height of instrument
Add the backsight reading to the known elevation of the station.

Step 8: Observe grid points
- Read foresight to 0.1-foot accuracy at all grid and key points if telescope is level.
- Read top wire reading, center wiring reading, and bottom wire reading to 0.1-foot accuracy if telescope is not level and measure vertical angle.
- Record values.
- Radiate level rod out to all points encompassing the complete grid.
- Read horizontal angle for any point of detail object.

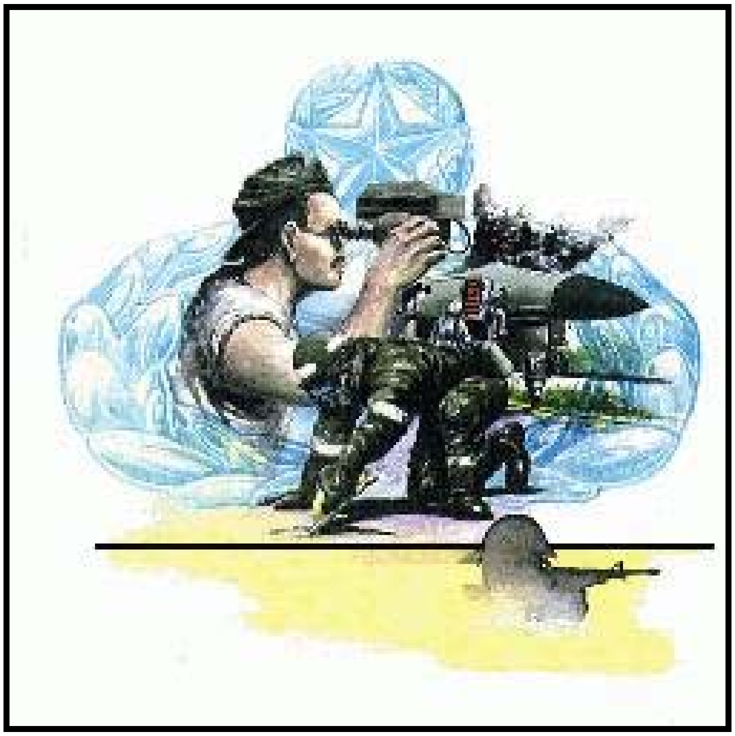
Review Questions
for
Perform Topographic Survey

Question	Answer
1. Resection, intersection, and radiation are three methods you can use to locate points in the field.	a. True b. False
2. What types of reconnaissance can be performed with topographical surveying?	a. Written Answer
3. Tapes and stadia measure horizontal distances.	a. True b. False
4. What accuracy can be expected from stadia distance measurement?	a. 0.1 foot b. right foot c. 3rd order accuracy d. 1 metric foot per day

PERFORM TOPOGRAPHIC SURVEY

Performance Checklist		
Step	**Yes**	**No**
1. Made map of the area?		
2. Selected correct topographic equipment?		
3. Established a baseline for the survey?		
4. Laid out grid?		
5. Set up and leveled instrument?		
6. Observed backsight?		
7. Computed height of instrument?		
8. Observed grid points?		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.



SURVEYING

MODULE 12 **AFQTP UNIT 5**

CONSTRUCT TOPOGRAPHIC MAP (12.5.)

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

CONSTRUCT TOPOGRAPHIC MAP

Task Training Guide

STS Reference Number/Title:	12.5. Construct topographic map
Training References:	• FM 5-233, TM 5-541; Surveying with Construction Applications, and Surveying Theory and Practice
Prerequisites:	• Possess as a minimum a 3E531 AFSC • Must have a basic knowledge of surveying and drafting prior to entering into upgrade • Must have completed volume 4. Plane Surveying of the 3E551A Engineering Journeyman Career Development Courses
Equipment/Tools Required:	• Calculator • Drawing media (vellum) • Pencils • Scales • Large triangle • Field notes
Learning Objective:	• The trainee will be able produce a topographic map
Samples of Behavior:	• The trainee will be able to plot contour lines • The trainee will be able to interpolate values
Notes:	
• Due to the availability of equipment and shop uniques, use established in-house steps and procedures to accomplish your hands-on training objective. This pamphlet is designed to reacquaint and/or jog your memory prior to initiating training in this area.	

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

CONSTRUCT TOPOGRAPHIC MAP

Background: The topographic map establishes enough relief and planimetric detail within the prescribed area to locate any obstacles and allow preparation of rough profiles and cross sections. A topographic map can be accomplished in either the *field* or *office*. Topographic mapping plays an important part in any construction operation. The resulting map that you or your subordinates create will affect the operation of the construction force in a beneficial way or a detrimental way, so care must be taken in the proper location of all natural and artificial feature and identification of elevations. For mapping large areas, modern photogrammetrical methods have almost entirely replaced field topographic surveying methods. Photogrammetric topographic maps are usually made for reproduction in large quantities at scales of 1:25,000 or smaller, with contour intervals of 10 feet or more. Regardless of modern advancements, small areas must often be mapped to a larger scale, and with a smaller contour interval by field topographic surveying methods

To perform this task, follow these steps:

Step 1: Determine map scale.
- Given a 17" x 22" paper size for a 200' x 200' site size.
- Compute map scale in inches to feet for an engineer scale.
- Length of project divided by length of paper.
- Width of project divided by width of project.

Step 2: Obtain drawing of area.
Use the drawing you produced during the topographic survey.

Step 3: Transfer data.
Transfer observed data from the field notebook to your drawing.

Step 4: Choose contour.
A contour interval of 0.5 foot will be used for map.

Step 5: Interpolation.
Interpolate between grid points to locate contour elevations.

Step 6: Produce contours.
- Connect equal elevations with smooth curve (hand drawn).
- Darken index contour.

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

Review Questions
for
Construct Topographic Map

Question	Answer
1. Topographic maps can be accomplished in the field and office.	a. True b. False
2. Photogrammetric topographic maps are usually made for reproduction in large quantities at scales of?	a. 1:5,000 b. 1:10,000 c. 1:20,000 d. 1:25,000
3. What contour line needs to be darkened?	a. Initial b. Intermediate c. Index d. None

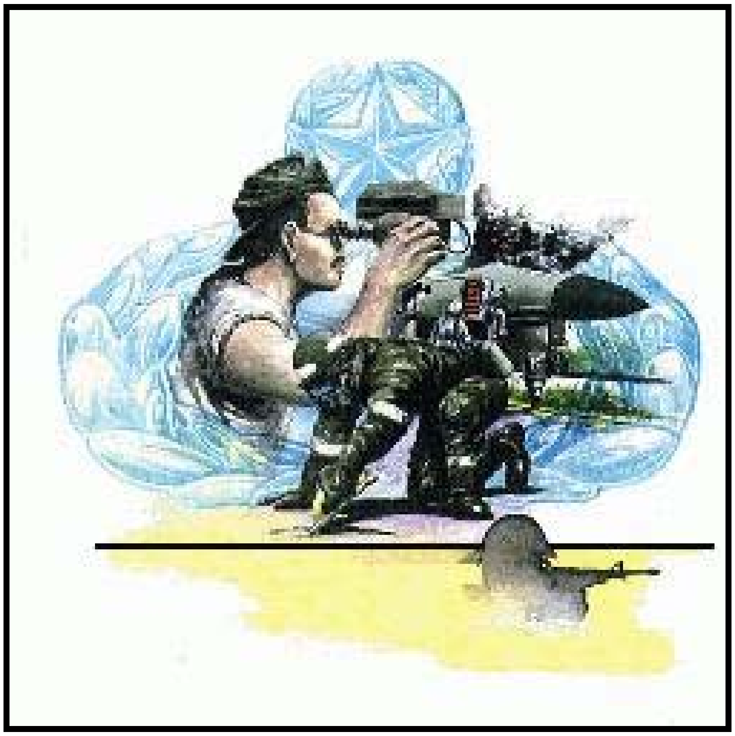
Notice. This AFQTP is _NOT_ intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

CONSTRUCT TOPOGRAPHIC MAP

Performance Checklist		
Step	**Yes**	**No**
1. Determined map scale?		
2. Obtained drawing?		
3. Transferred data?		
4. Choose contour?		
5. Interpolated?		
6. Produced contours?		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the minds of both the trainee and trainer.

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.



SURVEYING

MODULE 12 **AFQTP UNIT 10**

RECORD FIELD NOTES (12.10.)

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

RECORD FIELD NOTES

Task Training Guide

STS Reference Number/Title:	12.10. Record Field Notes
Training References:	• TM 5-230, TM 5-232, Surveying by Jack C. McCormac, 3E5X1 CDC
Prerequisites:	• Possess as a minimum a 3E531 AFSC • Must have a basic knowledge of surveying and drafting prior to entering into upgrade
Equipment/Tools Required:	• Notebooks, pens, pencils
Learning Objective:	• The trainee will be able to record field notes
Samples of Behavior:	• The trainee will be able to record instructions • The trainee will be able to record general sketch • The trainee will be able to record notes

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

RECORD FIELD NOTES

Background: Surveyor's field notes must contain a complete record of all measurements made during the survey; sketches, diagrams, and narrations should be made to clarify the notes. The best field survey is of little value if the notes are not complete and clear. The field notes are the only record that is left after the survey party departs the field survey site.

Recording All field notes must be lettered neat and legible. The lettering should be in free hand, *gothic style.* All notes should be in black or blue-black ink, suitable for photographic copying. However, in special cases a 3H or 4H pencil may be used. Numerals and decimal points should be legible and permit only one interpretation. Notes must be kept on the standard survey forms and not on scraps of paper for later transcription. The survey notes are usually kept in a field notebook. These notebooks are of two types: the permanent bound book and the loose leaf.

Field note recording takes three general forms; tabulation, sketches, and descriptions.

- **Tabulation** The numerical measurements are recorded in columns according to a prescribed plan depending upon the instrument used, order of accuracy of the survey, and type of measurement.

- **Sketches** Sketches add much to clarify field notes and should be used liberally. They may be drawn to scale or approximate scale or exaggerated for clarity. A planetable sheet is an example of a sketch drawn to scale. A control card sketch should be drawn to approximate scale and exaggerated when necessary to show important details needed for clarity. The measurements should be added directly on the sketch or keyed in some way to the tabular data. A very important requirement of a sketch is legibility.

- **Descriptions** Tabulations with or without added sketches can also be supplemented with descriptions. The description may only be one or two words to clarify the recorded measurements. It may also be a lengthy narration if it is to be used at some future date, possibly years later, to locate a survey monument.

Abbreviations and Symbols It is recommended that standard abbreviations, signs, and symbols be used in field notes. If there is any doubt as to the meaning or interpretation of a symbol or abbreviation, the words must be spelled out.

Corrections. ERASURES ARE NOT PERMITTED IN FIELD NOTES. A single diagonal line will line individual numbers recorded incorrectly out and the correct values added above. The circumstance of the correction of all original figures should be explained in the remarks column, except for obvious mathematical errors. No position will be voided or rejected in the field notes, except in the case of bumping the instrument or observing the wrong target, and then a note must be made in the remarks column stating the reason for void. Pages that are voided or rejected must be referenced to a substitute page. *This procedure for corrections is mandatory since field notes are considered legal evidence.*

Waterproofing. When working in parts of the world that are subject to high humidity and/or rain, it has been found that waterproofing of field notes can be accomplished in the field. This waterproofing can be accomplished by spraying a thin coat of acrylic clear plastic on the field record. This spray may be applied before the recording and it will make the paper waterproof, and it may still be written on with ordinary writing instruments. Field notes can be sprayed again after recording and the plastic then fixes the writing and prevents water damage to the records.

To perform this task, follow these steps:

Step 1: Record return instructions in front of the book if lost

Step 2: Create an index of field notes, and enter a logical title of the current survey

Step 3: List the party personnel and their duties

Step 4: List all instruments used, including serial numbers, calibration data, and date used

Step 5: Make a generalized sketch and description of project; be sure to include a north arrow with the sketch

Step 6: Label the columns for the numerical measurements as per figure 1; these headings will vary depending on the type of survey being performed and the type of instrument being used

Step 7: Enter the survey *measurement* notes

- On each page containing the measurement notes, the heading must be filled out to include station name, date, instrument man, recorder, instrument used, and, where pertinent, the weather.
- The body will contain all pertinent measurement notes. Each page must have the instrument man's initials on the bottom to indicate that he has checked the page for errors or omissions.

DESIGNATION PROJECT SAFB 10-2 DATED 30 AUG 1997

STA.	BS	HI	FS	ELEV.	DIST. BS	DIST. FS
BM72				300.73		
	6.73	307.46			250	
TP1			2.40	305.06		250
	8.35	313.41			230	
TP2			4.01	309.40		225
	2.43	311.83			300	
TP3			3.57	308.26		260
	5.62	313.88			280	
TP4			9.76	323.64		265
	0.97	324.61			305	
TP5			4.51	320.10		280
	6.47	326.57			190	
BM73			2.76	323.81		275

⊼ LYSENGEN
Ш WILLIAMS
ϕ LEASURE

SOKIA AUTO LEVEL
SN53431

CLEAR, CALM AND WARM

REMARKS

BM72 IS A CORPS OF ENGINEERS MONUMENT. BRASS DISC SET IN CONCRETE S78E OF INTERSECTION OF WALNUT STREET AND 15TH PLACE. ELEVATION 300.73'.

NOTE: ALL TURNING POINTS TAKEN ON STEEL PINS

BM73 IS A CORPS OF ENGINEERS MONUMENT. BRASS DISC SET IN CONCRETE N89W OF INTERSECTION OF PEANUT STREET AND 32ND LANE. ELEVATION 304.41'.

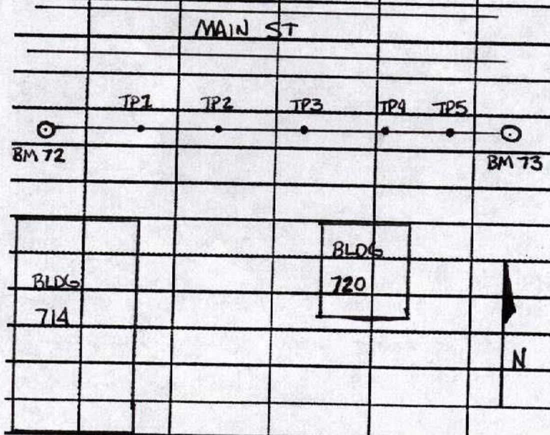


Figure 1

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

Review Questions
For

Record Field Notes

Question	Answer
1. What style of lettering should be used in the field notebook?	a. Gothic b. Times New Roman c. Ariel d. Roman Gothic
2. A complete record of all measurements, with necessary sketches, diagrams, and narrations to clarify the notes, should be found in a field notebook.	a. True b. False
3. What are the two types of notebooks used today?	a. Loose leaf and permanent bound b. Loose leaf and leather bound c. Tabulated and permanent bound d. Loose leaf and temporary bound
4. How are corrections made in the field notebooks?	Written answer

RECORD FIELD NOTES

Performance Checklist		
Step	**Yes**	**No**
1. Were instructions for return of lost book completed?		
2. Was survey entered into the index and given a logical name?		
3. Were party personnel and their duties entered in field notes?		
4. Was instrument information properly entered?		
5. Is sketch an accurate reflection of the project and does it include a north arrow?		
6. Are columns properly labeled for the survey performed?		
7. Are measurement notes pertinent and accurate data?		
8. Are all corrections properly made in notebook?		
9. Is all data required to repeat this survey available in the field notes?		

FEEDBACK: Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the minds of both the trainee and trainer.

Air Force Civil Engineer

QUALIFICATION TRAINING PACKAGE (QTP)

REVIEW ANSWER KEY

For

ENGINEERING

(3E5X1)

MODULE 12

SURVEYING

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

ESTABLISH HORIZONTAL CONTROL

(3E5X1-12.1.3.)

Question	Answer
1. What is a traverse?	The measurement of lengths and directions of a series of straight lines
2. What are the two kinds of traverse?	c. Open and Closed
3. North latitudes are positive and south latitudes are negative.	a. True
4. East departures are negative and west departures are positive.	b. False
5. What does the term closed traverse mean?	The end of the traverse closes on a known point
6. A closed traverse provides no checks against mistakes or large errors.	b. False

ESTABLISH VERTICAL CONTROL

(3E5X1-12.2.3.)

Question	Answer
1. What are the two methods for performing indirect leveling?	a. Trigonometric and barometric
2. What are the two major categories of Leveling?	c. Direct and Indirect
3. Backsights are always subtracted from the known elevation.	b. False
4. You should always attempt to balance your backsight and foresight distances.	a. True
5. To close a level circuit you may return to your starting point or continue to another point of known elevation.	a. True

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

PERFORM SITE RECONNAISANCE

(3E5X1-12.3.)

Question	Answer
1. What is the purpose of a reconnaissance survey?	To complete a comprehensive study of the entire area that might be used for construction
2. Preliminary studies include studying maps and gathering reports and data?	a. True
3. Air photos can yield extensive information on terrain, vegetation, water sources, obstacles, and site access?	a. True
4. Reports can be submitted orally and followed up with a written report?	a. True

PERFORM TOPOGRAPHIC SURVEY

(3E5X1-12.4.)

Question	Answer
1. Resection, intersection, and radiation are three methods you can use to locate points in the field.	a. True
2. What types of reconnaissance can be performed with topographical surveying?	Written Answer
3. Tapes and stadia measure horizontal distances.	a. True
4. What accuracy can be expected from stadia distance measurement?	a. 0.1 foot

CONSTRUCT TOPOGRAPHIC MAP

(3E5X1-12.5.)

Question	Answer
1. Topographic maps can be accomplished in the field and office.	a. True
2. Photogrammetric topographic maps are usually made for reproduction in large quantities at scales of?	d. 1:25,000
3. What contour line needs to be darkened?	c. Index

RECORD FIELD NOTES

(3E5X1-12.10.)

Question	Answer
1. What style of lettering should be used in the field notebook?	a. Gothic
2. A complete record of all measurements, with necessary sketches, diagrams, and narrations to clarify the notes should be found in a field notebook.	a. True
3. What are the two types of notebooks used today?	a. Loose leaf and permanent bound
4. How are corrections made in the field notebooks?	Never erase; line out the wrong information and write the correct information above it, and explain in the remarks column